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Thermoelectric generator for energy production from renewable sources

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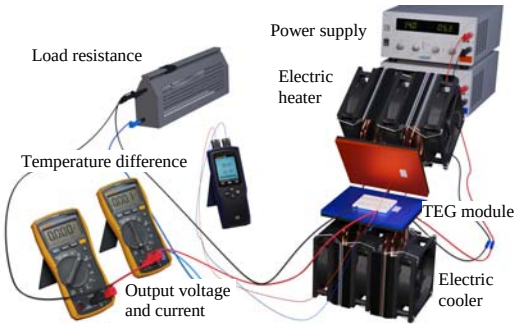
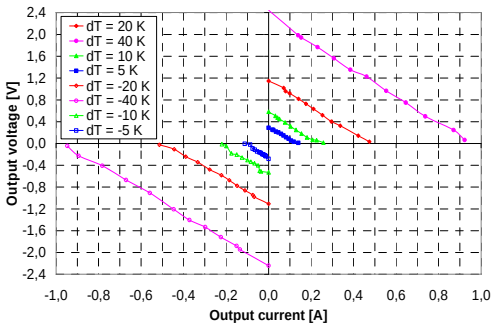
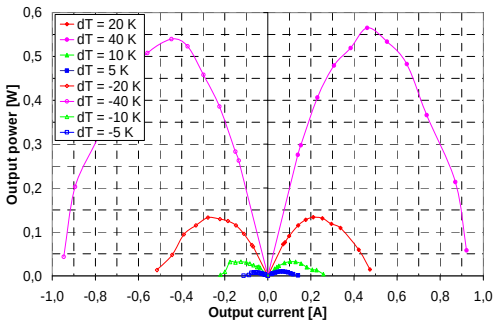
Experimental setup and measurement results

Experimental setup



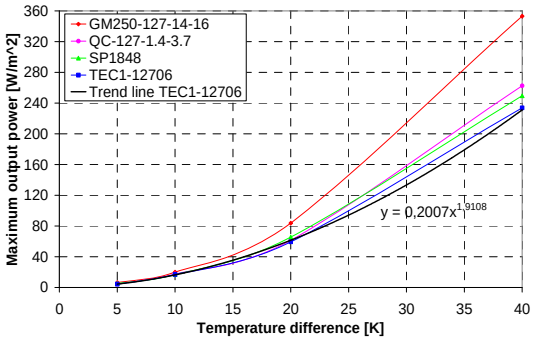
Output voltage and power of TEG module GM250-127-14-16 for different temperature differences between cold and hot side



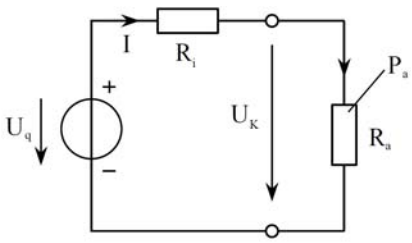


Electrical equivalent circuit

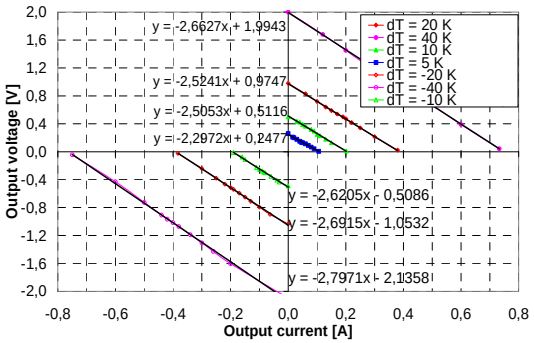
Maximum output power as function of temperature difference for TEG modules



Electrical equivalent circuit of a TEG module

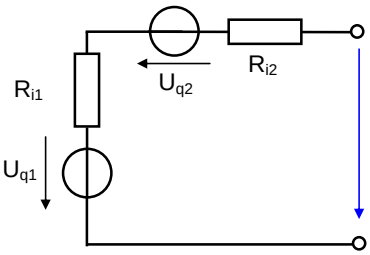


Output voltage of TEG module TEC1-12706 with straight line equation



From TEG module to thermoelectric generator

Series connection for different temperature differences

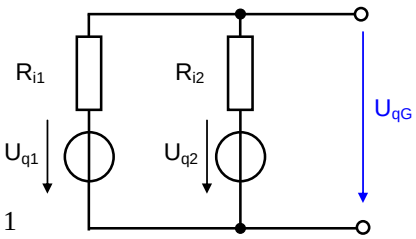


$$n + k = z$$

$$x = \frac{k}{z} = 0 \ldots 1$$

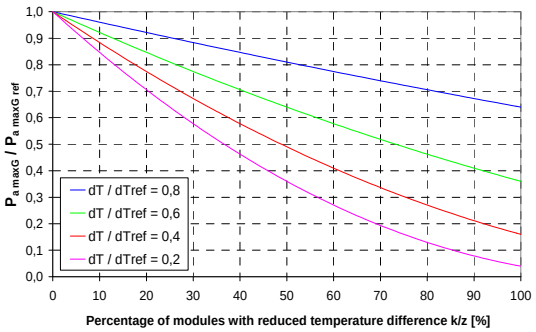
$$U_{qG} = z \cdot U_q \left(1 - x + x \frac{dT}{dT_{ref}}\right) \quad ; \quad R_{iG} = z \cdot R_i$$

Parallel connection for different temperature differences



$$U_{qG} = U_q \left(1 - x + x \frac{dT}{dT_{ref}}\right) \quad ; \quad R_{iG} = \frac{R_i}{z}$$

Output power reduction at reduced temperature difference



$$\frac{P_{a\,\max G}}{P_{a\,\max G_{ref}}} = \left(1 - \frac{k}{z} + \frac{k}{z} \cdot \frac{dT}{dT_{ref}}\right)^2$$

Results:

Output characteristic of a TEG module is characterized by an open-circuit voltage (U_q) and an internal resistance (R_i)

The open-circuit voltage is proportional to the temperature difference between cold and hot side, internal resistance is nearly constant

Output power has a maximum which increases quadratically with the temperature difference and linearly with the module area

At temperature difference of 40 K an output of 250 W/m² can be generated, with an usage time of 5000 hours per year

Photovoltaic modules can generate 150 W/m² in full sunlight, this output is only available for 1000 full-load sunshine hours per year

Thermoelectric generators have significant potential for the energy transition

Possible applications can be found in the natural environment (geothermal energy, solar thermal energy, deep heat), on buildings (roofs, facades), on large-scale process plants (waste incineration plants, combined heat and power plants, heat pumps, chimneys)

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